Implications of Industry 4.0 in Nigeria electoral system

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Abstract

Emerging research discusses the convergence of the physical worlds and digital transformations. Security trepidations related to the electoral system is a major challenge in developing countries. This research seeks to limit these security trepidations aligning with the recent digital revolutions. This research focuses on the implications of the fourth industrial revolution (4IR) relative to the electoral process in an African context. The impacts of the 4IR relative to automation, data analytics, innovation, Internet of Things (IoT), security, connectivity, and data exchange are enormous. With security trepidations experienced in any electoral process specifically in the African context. Aligning with the 4IR becomes an essential and priority to be integrated from concept, rollout and beyond during an election phase. This aims at limiting hacks, cybersecurity, breaches, and stolen identities. Nigeria as a subset in the Africa context is explored to investigate the implications of the 4IR related to the electoral process. The biometric technology and system workflow are specifically investigated resulting in a document, which becomes a significant tool for developing countries relative to electoral assessment and implementations.

Keywords
Biometric workflow, electoral system, fourth industrial revolution, security trepidations.

1. Introduction
The 4IR is upon us with a fundamental shift from traditional transformations, where automation, manufacturing technologies, data analytics, Internet of Things (IoT), and data exchange aims at simplifying the physical worlds (Chen, et al., 2018). The 4IR refers to a smart technology or system describing the current trend for automation and data exchange (Roblek, et al., 2016 and RuBmann, 2015). The 4IR is characterised with the emergence of digital transformations in Cyber-Physical Systems (CPS), IOT, Artificial Intelligence (AI), Internet of Services (IOS), robotics and Self-Monitoring Analysis and Reporting Technology (SMART) technologies (Dolgui, et al., 2018). The 4IR has significant impacts globally inclusive of economic, academic, business and electoral sectors. This research seeks to explore the implications of the 4IR related to the electoral system with a specific focus on Nigeria as a subset African country. Electoral systems are described as a set of procedures, which regulates how referendums and elections are conducted and how the results are established aligning with democratic principles. Emerging literature, roundtables and white paper publications establish challenges in Africa democratic process relative to electoral trepidations faced with significant security and authentication concerns (Baguma & Eilu, 2015 and Shah, 2015). There is a necessity to develop a smart structure to enhance the electoral system. The government, public and private practitioners ought to promote for a convergence of the 4IR towards enhancing the electoral system, aiming at positively influencing the security authentication process. This research seeks to highlight the practical and theoretical implications on the adoption of the 4IR specifically biometric technology related to the electoral system. The influences of the 4IR to mitigate the gaps of the biometric technology authentication expertise is discussed. This research is initiated with a discussion on 4IR implementations specifically the biometric technology. The first section identifies, defines and explores the existing relationship between the biometric system workflow. Secondly, this research highlights literature making a comparison between the advanced and developing continents with respect to the electoral process currently practiced. The challenges encountered with each electoral process is reviewed based on 4IR implementations. This research concludes by proposing future research directions, applications and suggesting recommendations relative to the research objectives.

2. Biometric Technology

The biometric technology aligns with the recent 4IR specifically considered in this research for enhancing the electoral authentication access of physical systems and installations. Authentication relative to the electoral process involves establishing the true identity of an electorate. This is the initial step prior to gaining access to physical installation or information systems. The biometric workflow presents automated value-add for capturing and verifying the identity of an individual (Das, 2014). This is based on individual uniqueness comprising behavioural, physiological, biological, morphological features (Wang, et al., 2016) and presents positive personal identification attributes of the individual. The adoption of the biometric workflow aligning with the 4IR has evolved rapidly over the years. There are significant advances with its adoption, which increases processing abilities and integration enhancing reliability, cost, and accuracy of the electoral process (Rao, et al., 2017). The biometric system workflow comprises two phases presented in Figure 1, which includes the enrolment phase and the testing phase (Tripathi, 2011).

- The enrolment phase develops a database of prototypes characterizing the authorized users. A user is assigned a single prototype. The enrollment phase comprises “Preprocessing”, “Extraction”, and “Storage”.
- The testing phase involves processes granting access to the authorized user. This is the phase where the physical devices are parametrized generating a prototype which is compared with the authorized user prototype. The testing phase includes “Preprocessing”, “Extraction” and “Matching” presented in Figure 1.

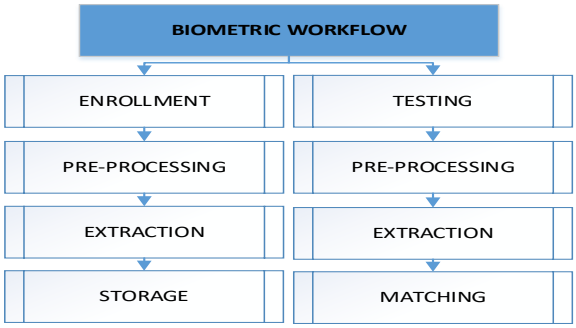

Figure 1. Biometric system workflow

Both enrolment and testing phases are implemented based on the first two sub-processes at different instances.

- Pre-processing develops a prototype of the specific user.
- Extraction highlights the best representative subset feature of the prototype developed.
- Storage refers to database generation where prototypes of the authorized individuals are stored.
- Matching seeks for identical verification of the individuals, which is dependent on a similarity check of already stored prototypes in the database.

A (2010) publication from the national research council and whither biometrics committee highlights on benefits of the biometric technology over traditional approaches. A synopsis of some of the benefits is presented.

(i) Obviates the need to transmit a token or remember a password.
(ii) Prevent unauthorized access to or fraudulent use of smart cards and devices such as ATMs, computer systems, cellular phones, workstations.
(iii) Promotes uniqueness, it is difficult to duplicate or distribute.
(iv) Require the individual being authenticated to be present at the point and time of authentication.
(v) Ease of measurability with simple practical instruments.
(vi) Biometric technology is very user-friendly.

Biometric system workflow is operationalised based on a dual real-time authentication process (Vorobyeve, et al., 2014). This includes the physical and behavioural biometrics authentication process. No biometric authentication process is superior to the other. A synopsis of each biometric authentication process is presented.

(a) **Physical biometric authentication:** This explores for physical attributes of the individual. Key constructs of the physical biometric authentication include finger/hand print, hand geometry, facial ID, iris scan, retina scan, DNA and vascular patterns.
(b) **Behavioural biometric authentication:** This investigates for behavior traits. Key constructs of the behavioural authentication include speech/voice, signature and keystroke/patterning.

A search in literature establishes very few numbers of developing countries have fully aligned with biometrics technology for electoral system authentication process. Despite aligning the electoral process with the biometric technology for authentication in Nigeria, security trepidations faced with authentication concerns still exist. The authentication concerns range from social philosophies, economic challenges and cultural beliefs (Baguma & Eilu, 2015 and Omotola, 2010). Emerging literature affirms the need for continuously investigating best practice measures enhancing ease of acceptability and applicability of the biometric technology (Aricat, 2015). This research explores the possibilities of adopting different combinations of the biometric real-time authentication relative to enhancing the electoral process. There is a need for electoral stakeholders to step back and re-evaluate key indicators relative to enhancing the electoral system. This is aimed at credible electoral outcomes contributing significantly to democracy's essential values inclusive of political accountability and equality.

3. Methodology

Electoral challenges differ from countries. Each country ought to implement specific electoral steps, which addresses current electoral state and transition to align the electoral process with the 4IR implementations to maximize benefits. Electoral stakeholders ought to develop an implementation structure allowing for regularly evaluating and improving an electoral process across numerous operational levels. An effectively modelled electoral system align, prioritize and activate on accomplishing key electoral objectives, allowing for expressive democracy pointers such as transparency, inclusivity, and accountability. The current limitations between collecting and analysing high-value electoral data and insights are mitigated when electoral stakeholders start implementing measures towards continuously evaluating the electoral process. The core methodology adopted in this research is systematic literature review from online databases related to 4IR, biometric technology and the electoral process as practiced in developing and advanced continents. Key indicators reviewed from literature include but not limited to:

(i) Duration of the electoral process.
(ii) Electorates participating in voting both onsite and in the diaspora.
(iii) Nomination, campaign, marking, casting and counting of ballots.
(iv) Security trepidations are inclusive of authentication, registration, training, education and planning process.
(v) Easy accessibility and online polls.

These indicators present a framework for exploring the implications of 4IR specifically biometric technology in enhancing the electoral process in developing countries. The sequential approach employed in this research adapted from (Wheeler & Winburn, 2015) is presented in Figure 2.

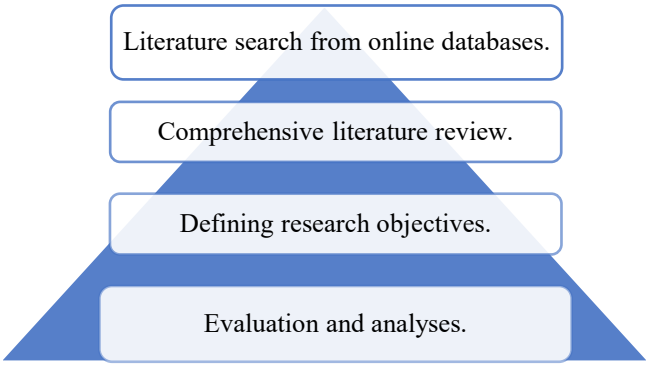

Figure 2. Research approach adapted from (Wheeler & Winburn, 2015)

Emerging literature discusses electoral systems as practiced in developed continents. This is highlighted and discussed in the next section.

4. Electoral Systems Practiced in Advanced Countries

This section reviews global current best practice electoral systems as practiced in some developed countries, which are often more democratic and modernized than what is obtainable in developing countries. A framework for making a comparison between the advanced and developing continents with respect to the electoral systems currently practiced is stimulated. The comparison facilitates a structure for identifying key physical tools and constructs essential for implementing an integrated electoral (online) system. Electoral systems are described as a set of procedures, which regulates how referendums and elections are conducted and how the results are established. This may be either a political electoral system associated with government institutions or non-political electoral systems organized by business entities or informal sectors. Electoral systems significantly influences who participates, loses and wins an election ultimately forming a government (Reynolds, et al., 2005). The electoral system is, therefore, a critical factor in implementing democratic principles in any given context. The foremost types of electoral system practiced across the globe as adapted from (Reynolds, et al., 2005 and Norris, 1997) is presented in Figure 3.

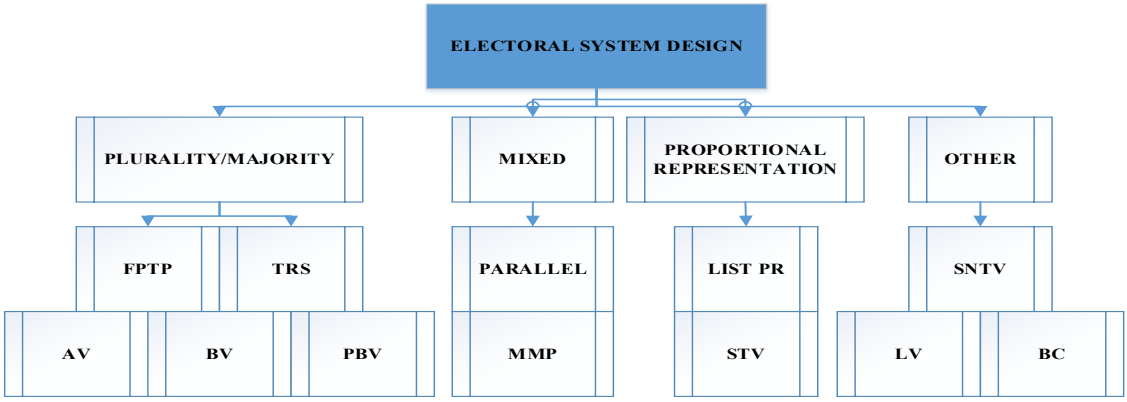

Figure 3. Electoral system design adapted from (Reynolds, et al., 2005 and Norris, 1997)

A synopsis of each fundamental electoral system presented in Figure 3 is detailed.

Plurality/Majority electoral system

A plurality electoral system is the most common method and operates optimally in a two-party system structure. Plurality describes an electoral process in which an aspirant seeking election who polls more votes than other contenders is elected despite not gathering majority (Vowles, 2010). This electoral system is distinguished from the majority electoral system in which the aspirants must gather more votes (above 50%) than all other candidates combined. Both electoral systems are comparable as the methods elect aspirants with most votes. The plurality/majority electoral system is as practiced in the United States of America (USA), Malaysia, France and the United Kingdom (UK). Some approaches of the plurality/majoritarian electoral systems are the First-Past-the-Post (FPTP), Two-Round System (TRS), Alternative Vote (AV), Block vote (BV) and Party Block Vote (PBV). An exploratory of each approach is presented in (Reynolds, et al., 2005).

Mixed electoral system

The mixed electoral system combines the plurality/majority and proportional electoral system describing an electoral structure in which electorates are provided two votes for legislation with an element of proportional representation (Manow, 2011). One of the votes decides legislatures for a single-seat constituency while the other vote is for political party affiliation as practiced in Romania 2008 and 2012 elections. The mixed electoral system balances the disadvantages and advantages of both the plurality/majority and proportional electoral system. The mixed electoral system is as practiced in Germany, Japan, South Korea, Russia, Azerbaijan, Bolivia, Georgia, and New Zealand. Some approaches of the mixed electoral system are the Parallel Mixed Member Majoritarian (MMM) and Mixed Member Proportional (MMP).

Proportional representation electoral system

Proportional representation electoral system reflects a voting structure in which divisions or political parties into elective positions is determined by the number of popular votes gathered. The proportionality representation electoral system is as practiced in countries like Belgium, Finland, Denmark, Switzerland, Spain, Sweden, Greece, Israel,

Hungary, Norway, Italy, Luxembourg, Austria, Northern Ireland, and Russia. Some approaches of the proportional representation electoral systems are the list Proportional Representation (PR) and Single Transferable Vote (STV).

Others
Certain electoral systems are adopted in multi-member districts. Some of the approaches include Single Non-Transferable Vote (SNTV) where each electorate casts one vote for an aspirant but unlike the FPTP approach, more than one seat is occupied in each electoral district and Limited Vote (LV) where the electorates have more than there are aspirants to be elected.

Any of the various forms of electoral systems is considered based on the various countries necessity in a specific context. The highpoints of each electoral system are the adoption of physical systems such as mobile phones as an authentication tool. The use of mobile phones aligning with the 4IR implementations for the election process in developing countries presents challenges and opportunities (Baguma & Eilu, 2015). Enhancing real-time authentication access via mobile phones based on 4IR implementations is essential. Mobile phones present ease of access for eligible electorates both onsite and in diaspora (off-site) to participate in an electoral process. The next section identifies and highlights five key constructs essential for implementing an integrated electoral (online) system via physical systems inclusive of mobile phones.

5. Key 4IR Constructs for Enhancing the Electoral System

The biometric system is a dynamic technological imperative on fundamental 4IR implementation constructs. This section identifies and explores five key constructs essential for enhancing the electoral process in Nigeria as a developing country in an African context. Five key constructs presented in Figure 4 which includes “capacity”, “ethics”, functionality”, “structure” and “data storage” are highlighted. The five key constructs are identified from a detailed technology review of the Massachusetts Institute of Technology (MIT) white papers publications.

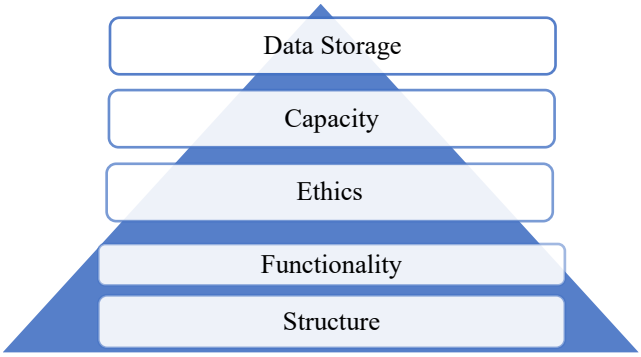

Figure 4. Key constructs of the electoral system

A synopsis of each key construct presented in Figure 4 aligning with proposed 4IR implementations is detailed.

Data storage
The electoral system gathers and stores large volumes of data throughout the execution of the electoral process both on and off sites across several geographical locations. This research proposes for a structure resulting in a comprehensive, focused data set for collection, analysis, and storage. An automated cloud storage structure aligning with 4IR implementations is essential towards advancing the electoral process in Nigeria as a developing country. Cloud storage is a 4IR technology effective for providing data supporting proactive and predictive opportunities (Slamanig & Hanser, 2012). Cloud system presents a model of data storage in which digital data is gathered in servers and logical pools with the physical environment possessed and managed by a hosting platform (Hart, et al., 2016). Rather than single data points at short intervals, the cloud storage system promotes the continuous stream of high-value data. A framework for managing high-volumes and magnitude of data is supported aligning with the 4IR implementations. Cloud storage system facilitates a structure for easy access to data for census, developing a social system of individuals and gathering opinion polls on national issues inclusive of economic, social, electoral, security and political concerns. Attributes of the cloud storage system relative to the electoral process adapted from (Roblek, et al., 2016) includes but not limited to:

(i) Scanning, capturing and storage of an analog/digital image of individual personal characteristics.
(ii) Compression, comparison and processing of an individual's image to a cloud database structure of stored images.
(iii) Interface with application structures.
(iv) Supports a structure for predictive analytics.

Benchmarks to be considered prior to developing an automated cloud storage structure as adapted from a publication accessible from the data protection ethics library on ethical issues in data management is detailed. These benchmarks enhance the success rate in developing and effecting an automated cloud storage structure.

(i) Anticipate how the data gathered will be utilised.
(ii) Develop and study the use case.
(iii) Retain raw data as raw.
(iv) Store collected data in open formats.
(v) Data ought to be structured for ease of analysis.
(vi) Data ought to be uniquely identifiable.
(vii) Link essential metadata.
(viii) Adopt efficient privacy protocols.
(ix) Develop a systematic backup structure.
(x) The location and approach of data storage are dependent on the quantity of data to be generated.

Capacity
Capacity describes the ability of the physical systems deployed for the electoral process to possess certain benchmark features. This research proposes for the authentication process of an electoral system to be integrated with the facial recognition feature. The effectiveness of facial recognition feature for authenticating, unlocking or granting access to a system is demonstrated in numerous applications. This is detailed in a (2009) publication from emerging trends in information technology. Facial recognition is a 4IR technology operationalised based on a structured light scheme deploying suites of sensors for capturing visage in three dimensions (3-D). The sensors activate an infrared light, which illuminates the face and stimulates a projector projecting an array of infrared dots. The infrared camera captures the infrared dots, which the electoral physical systems employ in authenticating an individual against a previously stored image of the individuals face in the automated cloud storage device. The facial recognition feature limits trepidations associated with electoral authentication and security (spoofing). There is one in a million chance an individual can spoof an already captured image in the automated cloud database. Aside from requiring a measure of the individuals' attention for authentication, it is configured with a realistic looking 3-D mask which is efficient in preventing spoofing. Benchmarks to be considered exploring capacity as a key construct related to the electoral process includes but not limited to:

(i) **Time:** The time between enrollment and authentication of an individual image.
(ii) **Position/Light conditions:** Visibility of occluding items such as glasses, hat, scarf, beards.
(iii) **Retina scanning:** Utilizes the unique patterns on individual retina blood vessels.
(iv) **Iris scanning:** Utilizes mathematical unique pattern recognition methods or near-infrared illumination on video images of an individual's eyes of both or one the irises.

The facial recognition capacity means an individual's face effectively serves as a barcode to authenticate and access an electoral system.

Functionality
The physical systems deployed for an electoral process are only efficient when electoral stakeholders are able to translate the capacity insights developed into functional programs delivering optimal returns. Functionality is the articulation of the benchmark conditions the electoral process requires to deliver and perform optimally. The government, public and private institutions prior to an electoral process ought to define the type of electoral system to be practiced. Functionality also includes ease of access for eligible electorates both onsite and in diaspora (off-site) to participate in an electoral process. Benchmarks to be considered exploring functionality as a key construct related to the electoral process includes but not limited to:

(i) Guidelines of the electoral system to be practiced between plurality/majority, mixed, proportional representation or others.

(ii) The time frame of the electoral process which includes planning, education, registration, training, and execution.
(iii) Easy accessibility of electorates participating in voting both onsite and in the diaspora.
(iv) Nomination, campaign, marking, authentication, casting and counting of ballots.

Data analytics and exchange is a 4IR implementation and can be employed in operationalising the benchmark conditions of functionality defined as a key construct related to the electoral process.

Ethics
The ethical principles governing each electoral structure is a key construct towards ensuring optimal execution and delivery of an election process. Ethics seeks for the availability of data protection rights that apply inclusive of safety and protection of an individual's information. Ethical principles aligning with the 4IR implementations is extensively discussed in literature (Kassner, 2017 and Timothy, 2017). Benchmarks to be considered exploring ethics as a key construct related to the electoral process includes but not limited to:

(i) **Beneficial:** This seeks to measure if the data usage benefits both the electorate and stakeholders. The electoral stakeholders ought to constantly define the expectations associated with data storage and usage promoting a framework for effective evaluation.
(ii) **Progressive:** Are there defined philosophies for data minimization and continuous improvements. If the projected enhancements can be accomplished in a less data-intensive method, then less-intensive processing is pursued. This promotes a sustainable and minimal risk analysis eliminating the disenfranchising of electorates.
(iii) Sustainable: Are the insights identified with the collected data sustainable over time. Sustainability enablers include data sustainability, device/manufacturer based sustainability, algorithmic sustainability.
(iv) Respectful: This measures if the stakeholders have been inclusive and transparent with the electorates. This includes the capturing, aggregation and regulation of data.
(v) Fair: This seeks to measure the potential impacts of captured data and usage on all electorates and stakeholders in the electoral process. Are there policies prohibiting discrimination relative to genetics, race, and gender.

This research suggests applying a pragmatic approach of the five ethical principles detailed in incorporating ethics into the electoral system.

Structure
Structure as a key construct relative to the electoral process seeks for an electoral model effective for wrangling, assembling and contextualizing data from multiple sources both offline and online. Configuring an operations-wide integrated and centralized electoral structure based on defined key constructs is effective for generating an overarching assessment of the effects and benefits of 4IR implementations relative to enhancing the electoral process. This ensures the comprehensive capturing, analysis and storage of a precise set of data. This key construct also seeks for the efficient assembly of an efficient management team with comprehensive knowledge on the execution of defined key constructs. If an efficient management team implements the appropriate electoral key constructs, positive electoral outcomes abound.

Synchronizing these key constructs on physical systems deployed for the electoral process is remarkable resulting in an easier structure for electorates to be involved in the electoral process across several locations connecting to a singular database. A structure for capturing a comprehensive, focused data set for analysis is supported. This research proposes physical systems that can be leveraged by migrants to effectively engage in the electoral process with their respective homelands. Developing an integrated electoral process based on key constructs discussed combining both the physical and behavioural biometric technology real-time authentication results to ease of access for electorates in the diaspora to effectively and securely participate in the electoral process, exercising civic rights and responsibilities.

6. System of systems
The indication of the system of systems is to develop an integrated electoral structure segregated into sub-systems representing key electoral constructs extensively detailed. The system of systems is developed based on 4IR biometric technology implementations. The sub-systems are configured with data set from each sub-system effectively communicating with another sub-system. This results in a framework for viewing the electoral structure holistically, which serves as an integrated decision-support paradigm for conducting and executing electoral decisions. This research facilitates for the development of a smart electoral structure in developing countries based on the integration of 4IR key constructs defined with modernized electoral systems as practiced in developed countries. Electoral

successes are evaluated among electorates on the indices of optimal participation in the electoral process. There is a necessity for the public, private and government institutions to develop and support an active structure enabling electorates fully participate in the process. An indication of the systems to systems framework is captured in Figure 5. The framework ought to be effective in allowing for migrants engagements in the electoral process, which can be achieved at various Nigeria consulates and high-commissions across the globe linked to a unified database. This is supported by the systems to systems framework, which allows for cloud storage and unified database obtainable from information sources such as driver's license, international passport, Bank Verification Number (BVN) and examination enrolments of qualified electorates.

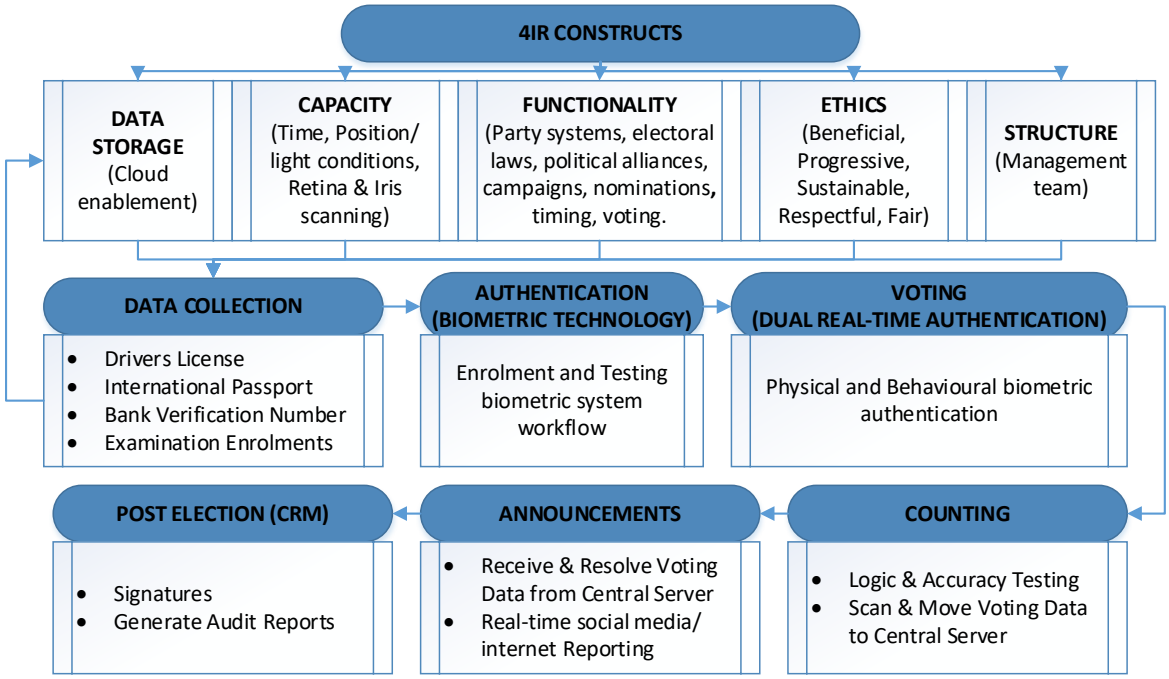

Figure 5. Systems to systems electoral framework

Driver's license, international passport, BVN and examination enrolments as sources of data collection can develop a comprehensive and reliable database of electorates limiting continual waste of resources requiring physical migrants' engagement for voters' registration and participation in the electoral process. This research discussed the implications of the 4IR implementations premised on biometric technology and mobile physical systems in enhancing the electoral process. The various forms of electoral systems practiced in advanced countries are highlighted. The choice of electoral system and authentication process has significant implications on the implementations of an electoral process. This includes evolving political parties or party systems, electoral laws, choice of the political alliances, campaigns, electoral timings, nomination, and voting. To understand how the electoral process function and be implemented, it is essential to explore the nature of the electoral system and its relationship relative to political parties and conduct. This information presents better understanding and possibilities of alternatives together with disadvantages and advantages when prospects for electoral reform arises. This research proposed a fundamental shift from the way the election process is practiced in developing countries specifically Nigeria. This research leverages and explores essential 4IR key constructs relative to enhancing the electoral process. The use of mobile phones or devices as a physical system for real-time authentication based on 4IR key constructs of the biometric technology is emphasised. Presumably, the objective of any electoral stakeholder is a free, fair and fully participated electoral process enhancing electoral outcomes. The fundamental constructs based on the 4IR implementations specifically biometric technology limits security trepidations and real-time authentication process. Despite the advantages of the 4IR implementations specifically biometric technology, there exist certain limitations. Such as spoofing. Spoofing describes individuals impersonating as others to gain illegal access to protected or sensitive assets. Developing an integrated electoral process based on key constructs discussed combining both the physical and behavioural biometric technology real-time authentication process limits this limitation. There is one in a million chance an individual can spoof an already captured image in the automated cloud database. There have however been several published types of research developing and advising on anti-spoofing measures and solutions (Manow, 2011).

Conclusion

There is essential for facilitating the evolution of the electoral process in developing countries towards 4IR implementations. An electoral structure developed on the basis of 4IR implementations enables electorate view the electoral process as a process and not an event. This limits manipulation, fraud, security anxieties, and violence. Exploring best practices relative to the measures electoral process dynamics is evaluated is critical in enhancing electoral reforms, democratic principles and realizing a genuine representation. This research focused on exploring the implications of the electoral system in Nigeria as a subset of the African context based on fourth industrial revolutions. 4IR implementations are the big unexploited current technological trends relative to the electoral structure. This research document is a significant tool for developing countries relative to electoral assessment and implementations. Electoral stakeholders must rethink and redevelop strategies to align the electoral process with the 4IR implementations. This research output seeks to mitigate the skepticism and mistrust experienced by electorates relative to the electoral process effectively representing democratic and civic interests.

References

Aricat, R. G. (2015). Mobile/social media use for political purposes among migrant laborers in Singapore. Journal of Information Technology & Politics, 12(1), 18-36.

Baguma, R., & Eilu, E. (2015). Using mobile phones in elections in developing countries: Opportunities and challenges. In Computing in research and development in Africa (pp. 251-265). Springer, Cham.

Chen, B., Wan, J., Shu, L., Li, P., Mukherjee, M., & Yin, B. (2018). Smart factory of industry 4.0: key technologies, application case, and challenges. IEEE Access, 6, 6505-6519.

Das, R. (2014). Biometric technology: authentication, biocryptography, and cloud-based architecture. CRC press.

Dolgui, A., Ivanov, D., Sethi, S. P., Sokolov, B. (2018). Scheduling in production, supply chain and Industry 4.0 systems by optimal control: fundamentals, state-of-the-art and applications. International Journal of Production Research. 1-22. DOI. 10.1080/00207543.2018.1442948.

Gopal, A., & Singh, C. (2009). e-World: Emerging Trends in Information Technology. Excel Books.

Guerin, S. "Ethical Issues in Data Management". https://www.ucd.ie/t4cms/Data_protection_ethics_library.pdf. Accessed 5th April 2018.

Hart, E. M., Barmby, P., LeBauer, D., Michonneau, F., Mount, S., Mulrooney, P., ... & Hollister, J. W. (2016). Ten simple rules for digital data storage.

Kassner, M. (2017). "5 ethics principles big data analysts must follow". https://www.techrepublic.com/article/5-ethics-principles-big-data-analysts-must-follow/. Accessed 23rd March 2018.

Manow, P. "The cube rule in a mixed electoral system: disproportionality in German Bundestag elections". West European Politics, 34(4), 773-794, 2011.

National Research Council, & Whither Biometrics Committee. (2010). Biometric recognition: challenges and opportunities. National Academies Press.

Norris, P. "Choosing electoral systems: proportional, majoritarian and mixed systems". International political science review, 18(3), 297-312, 1997.

Omotola, J. S. (2010). Elections and democratic transition in Nigeria under the Fourth Republic. African Affairs, 109(437), 535-553.

Rao, S. P., Panetta, K., & Agaian, S. S. (2017, May). A novel method for rotation invariant palm print image stitching. In Mobile Multimedia/Image Processing, Security, and Applications 2017 (Vol. 10221, p. 102210N). International Society for Optics and Photonics.

Reynolds, et al., "Electoral System Design: The New International IDEA Handbook (Stockholm: International IDEA, 2005)". Accessed April 2018.

Roblek, V., Meško, M., & Krapež, A. (2016). A complex view of industry 4.0. Sage Open, 6(2), 2158244016653987.

Rüßmann, M., Lorenz, M., Gerbert, P., Waldner, M., Justus, J., Engel, P., & Harnisch, M. (2015). Industry 4.0: The future of productivity and growth in manufacturing industries. Boston Consulting Group, 9(1), 54-89.

Shah, S. (2015). Free and fair? Citizens' assessments of the 2013 general election in Kenya. Review of African Political Economy, 42(143), 44-61.

Slamanig, D., & Hanser, C. (2012, December). On cloud storage and the cloud of clouds approach. In 2012 International Conference for Internet Technology and Secured Transactions (pp. 649-655). IEEE.

Timothy, D.R. "Elections, Electoral Systems and Party Systems, A Resource Guide". (Stockholm: International IDEA, 2017)". https://www.idea.int/gsod/files/IDEA-GSOD-2017-RESOURCE-GUIDE-ELECTIONS.pdf. Accessed April 2018.

Tripathi, K. P. (2011). A comparative study of biometric technologies with reference to human interface. International Journal of Computer Applications, 14(5), 10-15.
Vorobyeva, I., Guriel, D., Ferguson, M., & Oladapo, H. (2014, March). Benefits and issues of biometric technologies. Are biometrics worth using?. In IEEE SOUTHEASTCON 2014 (pp. 1-8). IEEE.
Vowles, J. "Electoral system change, generations, competitiveness and turnout in New Zealand, 1963–2005". British Journal of Political Science, 40(4), 875-895, 2010.
Wang, S., Wan, J., Li, D., & Zhang, C. (2016). Implementing smart factory of industrie 4.0: an outlook. International Journal of Distributed Sensor Networks, 12(1), 3159805.
Wheeler, A., & Winburn, M. (2015). Cloud storage security: A practical guide. Elsevier.

Citations:

to this paper should be made as follows: Medoh, C. and Telukdarie, A. (201…) 'Fourth industrial revolution: Implications for electoral system in an African context, Proceedings of the international conference on Industrial Engineering and Operations Management, Vol. …., No. …., pp ….Toronto, Canada, October 23-25, 2019.

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